APPENDIX F

Phytolith Analysis of Soils from the Delaware Park Site

INTRODUCTION

Phytolith analysis is a technique new to Archaeology. Used by soil scientists and botanists over the last quarter century to study a variety of problems, including past vegetational distributions and climates (Jones and Beavers 1964; Witty and Knox 1964; Wilding and Drees 1971; Parmenter and Folger 1974), the technique has been applied to archaeological soils only within the last several years. It has been used to study the environmental history of sites in North America (Robinson 1978; Carbone 1977) and to document the presence of maize in archaeological soils from Ecuador (Pearsall 1978; Piperno 1980a) and Panama (Piperno 1980b). Though still very much in an embryonic stage in archaeological research, the technique holds great promise for documenting the presence of economically important plants and vegetational changes.

Phytoliths, also referred to as plant opal, are microscopic bodies of silica that are formed in the cells of living plants and then released into the soil following death and decay of the plant. Because they are mineral in composition they are resistant to the various environmental processes that often destroy organic and carbonized plant material in soils. By isolating phytoliths from soils and comparing their shapes and sizes to those from comparative plant collections, it is possible to identify the type of plant that contributed opal to the soils.

Phytolith studies have shown that monocotyledonous plants generally contain 10 to 20 times the silica content of dicotyledons and that there is a redundancy in phytolith morphology that often makes it difficult to identify the species of plants from phytoliths isolated from soils. Many plant groups, however, such as grasses (Metcalfe 1960), sedges (Metcalfe 1971), palms (Tomlinson 1961) and deciduous (Geis 1973) and coniferous(Brydon, et al. 1963) tree types produce distinctive silica types and many plant groups have not been studied at all. Intensive taxonomic studies of particular plants from specific areas will provide more specific morphological criteria for phytolith identification.

One area where intensive taxonomic work has proven successful is the identification of phytoliths from maize (Zea mays L.). Maize belongs to the Panicoid or tall grass sub-family of grasses, in part, because the epidermal cells that occur over the veins of its leaf characteristically form "cross-shaped" phytoliths. Pearsall (1978, 1979) provided distinguishing criteria for the identification of maize phytoliths in soils by demonstrating that maize cross-shaped phytoliths are consistently and significantly larger in size than those from wild grasses. Using four size categories: small (6.87 - 11.40 microns), medium (11.45 - 15.98 microns), large (16.03 - 20.56 microns) and extra-large (20.61 - 25.19 microns) she found that large and extra-large sized cross-shapes were very characteristic of maize. In contrast, only a few species of wild Panicoid grasses, out of over 70 tested, produced large-sized cross-shapes in percentages that ranged from 3.7 to 6.7 percent. These are much smaller than in the races of maize studied (an average of 30 percent) (Pearsall 1978). Extra-large sized cross-shaped phytoliths were not found in any of the wild grasses. Pearsall also showed that cross-shaped phytoliths

occur much more frequently in the maize leaf, than in the leaves of wild Panicoid grasses.

I tested Pearsall's technique using maize and a number of wild grasses and domesticated Old World Panicoid grasses that I collected in Panama during the summer of 1979. I found that the size criteria used to differentiate maize phytoliths were valid. Table 1 shows the size distributions of the cross-shaped phytoliths from these grasses (from Piperno 1980b). The study of the Panama grasses also showed that cross-shaped phytoliths occur much more frequently in maize than in wild grasses.

Analysis of the Delaware Park Soils

The date of the introduction of maize to the Eastern Woodlands is a matter of some importance. The phytolith study of the soils from the Delaware Park site (7NC-E-41) was undertaken to provide some information on this problem. A total of 17 samples from 16 different features were processed. Radiocarbon dates from these features range from 1850 $\pm$ 100 B.C. to A.D. 640 $\pm$ 155. Although phytoliths were abundant in these samples, none from secure proveniences yielded evidence for the presence of maize. Table 2 shows the proveniences of the samples that were analyzed and the size distributions of the cross-shaped phytoliths that were isolated from these samples. Table 3 shows the percentages of cross-shaped phytoliths of all sizes from these samples.

Two samples were analyzed from Feature 59. One, at 0-20cm. showed evidence for maize as 18% of the cross-shaped phytoliths fell into the maize large-size category. This figure is much larger than that reported from wild grasses. This sample, however, may well have been contaminated with modern surface soil which at one time was under maize cultivation. A deeper sample from Feature 59, at 40-60 cm. showed little evidence for maize, as only 1 out of 14, or 7%, of the cross-shaped phytoliths fell into the maize size category. This figure is well within the values obtained from wild grasses. It can also be noted that a higher percentage of cross-shaped phytoliths of all sizes occurred in the upper-most sample from Feature 59. The remainder of the samples showed no evidence for maize, since few to no large cross-shaped phytoliths were observed in them. Very few cross-shaped phytoliths of any size were isolated from these samples.

The phytoliths that were isolated from the soils came from a variety of plant types. Silicified epidermal cells from grass leaves were the most common form. At present, these can be differentiated to the sub-family level. The Panicoid sub-family, characterized by cross, dumbbell and acutely angled shaped phytoliths, includes the tribes Maydeae, Andropogoneae, Paniceae, Isacheae, and Oryzeae. The Chloridoid (short grass) sub-family produces varieties of saddle-shaped silica bodies. The tribes Chlorideae, Eragrosteae and Sporoboloeae are included in this group. The Festucoid sub-family has phytoliths which are circular, rectangular, elliptical, or oblong and includes the tribes Festuceae, Hordeae, Aveneae and Agrostideae.

Phytoliths from each of these sub-families were very common in the deposits. Sedge phytoliths, differentiable at present to the family level,

and sponge spicules occurred frequently. The combination of Festucoid grasses, which grow in well-watered areas, sedge and sponge spicules suggests that a source of fresh water was nearby. Phytoliths from monocotyledenous and dicotyledenous herbs were present. A number of phytoliths which presently cannot be assigned to type also occurred.

The fact that phytoliths were well-preserved in these soils is an encouraging sign. When comparative phytolith collections are worked out for northeastern vegetation and cultivated plants, the archaeological phytolith record should prove to be a very valuable tool for the reconstruction of prehistoric plant subsistence and environment.

SUMMARY

Although phytoliths were well-preserved in the soils, no evidence for maize was found. The maize phytoliths isolated from the top of Feature 59 probably originated from modern soil, which once supported a maize field. Further phytolith study of northeastern archaeological deposits should be undertaken. Since pollen and other plant material are often not preserved in archaeological soils from this area, phytolith analysis may well provide the answer to when maize and other cultigens were first grown here.

Table 1

	Dumbbells	Cross-Shaped Phytoliths		
		Small	Medium	Large
Zea mays	81	12	71	36
		10%	60%	30%
Saccharum (Sugar Cane)				
	277	10	11	2
		43%	48%	9%
Sorghum				
	167	30	4	0
		88%	12%	0%
Oryza (Rice)				
	194	3	3	0
		50%	50%	0%
Wild Grasses				
Cenchrus				
	489	11	0	0
		100%	0%	0%
Pennicetum				
	433	54	21	2
		70%	27%	3%
Paspalum				
	181	19	0	0
		100%	0%	0%
Paspalum				
	458	26	17	0
		60%	40%	0%
Panicum				
	486	12	2	0
		86%	14%	0%

	Cross-Shaped Phytoliths		
Melinis	Small	Medium	Large
Dumbbells	6	0	0
496	100%	0%	0%
Digitaria			
Dumbbells	3	1	0
496	75%	25%	0%
Setaria			
Dumbbells	84	40	2
374	67%	31%	2%
Andropogan			
Dumbbells	87	37	9
377	65%	28%	7%
Eleusine			
Saddle-Shapes	0	0	0
200			

Table 2

Size Distributions - Cross-Shaped Phytoliths from Delaware Park Soils

Level	Size		
	Small	Medium	Large
Feature 59 0-20 cm.	12 43%	11 39%	5 18%
Feature 59 40-60 cm.	4 29%	9 64%	1 7%
Feature 43 20-40 cm.	2 100%	0 0%	0 0%
Feature 138 30-40 cm.	4 50%	4 50%	0 0%
Feature 12 30-40 cm.	1 50%	1 50%	0 0%
Feature 70 40-50 cm.	5 46%	5 45%	1 9%
Feature 42 40-60 cm.	1 100%	0 0%	0 0%
Feature 63 40-60 cm.	2 67%	1 33%	0 0%
Feature 55 50-60 cm.	1 50%	1 50%	0 0%
Feature 56 50-60 cm.	0 0%	1 100%	0 0%
Feature 94 60-80 cm.	2 100%	0 0%	0 0%
Feature 39 60-80 cm.	No cross-shaped phytoliths observed		
Feature 149 60-70 cm.	7 54%	5 38%	1 8%

Level	Size		
	Small	Medium	Large
Feature 194 70-80 cm.	No cross-shaped phytoliths observed		
Feature 45 80-90 cm.	No cross-shaped phytoliths observed		
Feature 62 80-90 cm.	No cross-shaped phytoliths observed		
Feature 51 80-100 cm.	No cross-shaped phytoliths observed		

Table 3

% of Cross-shaped Phytolith of all sizes

Level	No. of Phytoliths	No. of Cross-Shapes	% of Cross-Shapes
Feature 59 0-20 cm.	2,700	28	1.0%
Feature 59 40-60 cm.	8,000	14	0.2%
Feature 43	7,200	2	0.03%
Feature 138	6,000	8	0.1%
Feature 12	1,800	2	0.1%
Feature 70	6,000	11	0.2%
Feature 42	3,600	1	0.03%
Feature 63	2,100	3	0.1%
Feature 55	3,600	2	0.05%
Feature 56	1,200	1	0.08%
Feature 94	1,800	2	0.1%
Feature 39	600	0	0%
Feature 149	14,400	13	8.1%
Feature 194	900	0	0%
Feature 45	600	0	0%
Feature 62	1,500	0	0%
Feature 51	660	0	0%

Methods of Analysis

a. Extraction of Modern Plants

Phytoliths are extracted from modern plants by the wet oxidation method. Leaf samples are digested by boiling them for 2 hours in a solution of 3 parts nitric acid to one part saturated potassium chlorate. After boiling, the phytolith suspension is washed in distilled water, in a 1N solution of hydrochloric acid, in distilled water again and then in acetone. The dried phytolith fraction is mounted on slides in Canada Fir Balsam.

b. Extraction of Soils

Soil samples are first deflocculated by periodic shaking over several days in a 5% solution of Calgon. The samples are than wet sieved through a 270 mesh screen to remove the sand portion, defined as the soil fraction greater than 50 microns in diameter. Clay, or soil particles less than 5 microns in diameter are then removed by gravity sedimentation using limiting times published in Jackson (1956). The remaining silt fraction of the soil, in which most of the phytolith content occurs, is fractionated into fine (5-20 micron) and a coarse (20-50 micron) silt fraction. This is done again via gravity sedimentation, using the technique and limiting times in Jackson (1956). Samples weighing from 1 to 2 grams are treated with a 10% solution by hydrochloric acid to remove carbonates, concentrated nitric acid to remove organic material and distilled water. A heavy liquid solution of specific gravity 2.3 is made by boiling down a saturated solution of potassium and cadmium iodide. 10 ml. of this solution is added to the samples. After mixing and centrifugation, the floating phytolith fraction is removed, washed twice in distilled water, dried quickly with acetone and mounted on slides in Canada Fir Balsam. A petrographic microscope at a magnification of 315x is used for phytolith counting.

For this analysis, the fine silt fraction of the soil, where the diagnostic maize phytoliths occur, was extracted.

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